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ABSTRACT

A review of the literature indicated that some studies had investigated the effects of light on learning, but that learning style preferences for bright or low light had not been studied in relation to academic achievement. This relationship was studied with fourth-graders in a suburban school in New York State. Students took the Learning Styles Inventory of R. Dunn and others (1979) to indicate their preferences for concentrating in bright or dimly lit areas. Thirty-two of the students tested revealed extreme preferences for one condition or the other (approximately 9% of the total population of fourth-graders in the district). These 32 students were tested for reading speed and accuracy on a standardized test in an extremely bright and then in an extremely dim instructional setting. Scores on both speed and accuracy were considerably better when the environment matched the student's diagnosed learning style preferences for light. The results are discussed in terms of their implications for classroom illumination and the influence of light on human mood. There are 49 references. (SLD)

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The National Society for the Prevention of Blindness in the United States investigated the importance of environmental lighting for school children. Its 1963 report verified that visual efficiency had a marked effect on many academic outcomes and that, it in turn, was influenced by a number of extremely important factors, including: (a) the stage of growth and development of the eyes; (b) the presence or absence of eye defects; (c) the presence and amount of glare, which often resulted from lighting reflected on classroom items such as desk tops; and (d) the relative brightness of objects and their backgrounds-- such as the contrast between environmental objects and classroom walls, floors, or ceilings (p. 10).

At approximately the same time, one of the first published reports concerned directly with the effects of lighting conditions on eventual achievement was authored by Rennhackkamp (1964) whose attention was directed toward insuring that school children be permitted to exert minimum effort and, simultaneously, demonstrate maximum performance. Because of extensive observations of the

strain and fatigue evidenced by South African students in relatively poor lighting, that researcher hypothesized that better illumination would produce increased academic achievement.

Four years later, Wurtman (1968) alerted educators to the fact that, "environmental lighting exerts profound biological effects on humans, in addition to providing the visual stimulus" (p. 523). Apparently, light penetrates the eyes and acts to control several glands and many metabolic processes. Furthermore, it "serves as the dominant timer, or synchronizer, for biological rhythms which result from oscillations that originate within the body" (p. 524), substantiating that environmental lighting can produce marked, and sometimes pathologic, changes in metabolism.

Wurtman's findings magnified the importance of lighting for if, in fact, illumination does interact with Time of Day circadian rhythms, it exercises an even more potent impact on individuals than previously suspected. The Lynch (1981) and Virostko (1983) research on the effects of Time on achievement suggest that Time is one of the most crucial elements of learning style. Given the data elicited by Wurtman and later synthesized by Rosenfeld (1977), it is difficult to understand why so few studies exist where the primary focus was on classroom illumination as it affects the academic performance of individuals, rather than groups.

At the University of Southern California, Knirk (1970) reported that the importance of providing an appropriately lit environment for instructional tasks could not be overestimated because of:

(a) the degree to which it affected students' ability to perceive stimuli; and (b) the influence it exerted on both attitude and performance. Knirk hypothesized that inappropriate illumination levels "abuse the human eye and have unfortunate physiological consequences" (p. 10). He also maintained that classroom lighting levels should never be below 30 footcandles and that "special tasks such as sewing should have a minimum of 50 footcandles" (p. 35).

It should be noted that, although the above cited authors evidenced extreme concern with appropriate illumination environments for school children, their writing reflected no recognition that different individuals might need more or less light than others. There were researchers, however, who demonstrated initial concern with individual needs for varying degrees of light; among those were Harmon (1949); Koppes (1962); Shaver (1968); Singel (1969); Westerberg (1975); and Wilson (1969). Apparently the potential impact of lighting had sufficient face validity that selected educators did not hesitate to publish their suspicions. However, no experimental studies were conducted to determine the degree to which those persons' hypotheses were correct.

Bass (1973) went further than most researchers in the early 70's. He insisted that:

> the lighting of a school building should be considered an active element of the total educational environment. In addition to ensuring efficient performance of visual tasks, a good lighting system contributes significantly to the aesthetic and psychological character of the learning space. (p. 8)

Corroborating that hypothesis, McVay (1971) affirmed that, through proper management of the sensory factors inherent in any classroom environment, teachers could improve student comfort, development, and academic performance. Again, those statements were beliefs that, as yet, had little research support. Apparently, the concept was taking hold for, in 1972, Horton suggested that the ability of individuals in school to concentrate on instruction was influenced strongly by factors like lighting. He urged that classroom designs consider individual needs-- but did not specify either what those needs might be or how they might differ among youngsters in the same grade, of the same age, by gender, or so forth.

During that same period, the chairperson of the School and Lighting Committee of the Illuminating Engineering Society reported that "the single standard of a minimum brightness level is no longer acceptable for classroom lighting" (p. 21). Falk (1972) asserted that previous standard had become obsolete and stated that:

> Classroom lighting design plays a particularly critical education role because of the direct relationship between good lighting and a student's performance....since the easier it is to see the printed or written word on paper, the more quickly and accurately the word can be identified. Given two persons who are relatively similar in every way and relatively equal in learning potential and seeing potential, the one who can see more comfortably will read and write more quickly and accurately and with less possible eye fatigue than the one who is trying to perform exactly the same task under less than adequate seeing conditions. (p. 21)

Once researchers became aware of the relative effects of varying illumination levels on groups, they began examining the differ-

ent kinds of lighting being employed in classrooms and their relative impact-- not on individuals-- but on group norms. Bartholomew (1972) analyzed the educational implications of using full-spectrum light which closely approximates natural sunlight, and a cool-white fluorescent light, commonly used in institutional settings, on undergraduates' achievement levels. Four classes of a single teaching assistant were used and each class' performance was compared against itself under different lighting conditions. Data were gathered with video-tapes during each seminar and with questionnaires after each session. The results indicated that no differential effect existed between self-reported attitudes or videotaped behaviors attributable to the respective lighting conditions. At the end of the experiment, the fifty eight undergraduate students were asked to judge their overall preference for one light or the other. No significant preferences were revealed; however, there was a clear difference in the qualitative characteristics of the lights when direct observations and appraisals were made. The students, it should be noted, were neither randomly selected nor assigned to treatment groups, nor were their preferences for varying light levels identified and then either matched or mismatched. Therefore, the design and resultant lack of statistical significance is questionable and subsequent research concerning the possible educational effects of differently illuminated environments was necessary.

By 1973, Kleiber had conducted two different experiments at Cornell University testing the general question of whether natural

light-- rather than a cool-white light-- would have a different effect on classroom behavior and the ability to concentrate in a conventional setting.

Fifty-nine undergraduates participated in the first experiment that utilized an eight-week counterbalanced design. Videotapes of classroom behaviors and postseminar questionnaires revealed no significant difference among variables concerned with classroom interaction, seminar effectiveness, and mood. A follow-up questionnaire did indicate, however, that upon direct appraisal, the natural light was perceived as more stimulating than the relatively harsh and brighter, cool-white, conventional light source; the natural illumination also was considered softer and more relaxing. However, at no point was individual preference for light considered and, therefore, the effect of different light levels and kinds on specific people was not a consideration of that study either.

Using a similar research design, the second experiment revealed that, on physiological measures, most subjects evidenced less fatigue after a study session in natural light than in a traditionally illuminated instructional environment. A newly designed graphing technique was used to illustrate and support the data analysis. Implications were hypothesized concerning the use of that environmental information for groups-- rather than for specific individuals based on identified light preferences.

Kleiber's findings substantiated those of Ott (1964), Seagers (1963), and Wurtman (1968), all of whom had indicated that sole

reliance on artificial lighting could have negative biological consequences. Those may have been the first indications that lighting was either susceptible to or causative toward genetic differences among individuals. By 1974, LaGiusa had substantiated that "more efficient light sources could be used to serve changing educational techniques" (p. 54). In light of rising national concern for effective energy management during this decade, educators have become obliged to use the most efficient illumination sources available. "Deliberate manipulations of brightness patterns to enhance the impact of visual stimuli, while optimizing energy usage, is virtually a virgin ground in schools" (p. 54). As such, LaGiusa was a forerunner of his time; he concluded that, in many schools, modifications of the lighting system could result in economic savings while, concurrently, "providing an improved learning environment through better vision, visual impact, and comfort" (p. 55).

Despite the increasing national awareness of light as a source of energy, research conducted in 1974 (Mayron, Ott, Nations & Mayron) revealed that very few teachers were aware that lighting could produce differing biological reactions in human beings. That study was designed to reveal differences in effects on people of varied types of lighting. However, once again, alternate lighting systems were used on everyone in the population; no attempt was made to differentiate among those students who either preferred a brightly-- or dimly-- illuminated instructional environment. Results indicated no significant differences in academic achievement in

alternative lighting conditions by subjects' gender. Apparently, boys and girls manifested essentially similar reactions to different illuminating conditions. Despite the inappropriate design caused by the lack of identifying individual preferences for selected lighting environments, many students did achieve better when they were tested in classrooms with 85 or more footcandles of light, in contrast with their scores in a fewer than 65 footcandle environment; others achieved less well. Academic achievement was determined by tests administered three times during the term-- at the end of the second and third grading period and then, again, at the end of the semester. The instrument employed was the SCORE, a test based on student performance objectives at 18 achievement levels in reading and perceptual motor skills.

Despite the dirth of experimental studies in educational settings, one investigation did link students' biologically imposed needs for specific illumination levels with complementary instructional environments. It was conducted at the University of New Mexico to observe and report the influence(s) that classrooms exert on student achievement. That document concluded that "the best curriculum and the highest hopes have little chance of being realized unless the stage for learning is appropriately set" (Rosenfeld, 1977, p. 167). That text suggested that classrooms should be examined with the scrutiny that a scene designer directs toward a bare stage; elements that lend themselves to manipulation should be directed toward ensuring heightened comfort and pleasure

to permit children to relax and concentrate on learning. "We can affect the arrangement of chairs, desks, tables, work spaces, and other aspects of the set; we can control the colors, lighting, and heat which surround us" (p. 167). Certainly, the results of experimental studies concerned with the effects of sound, (Pizzo, 1981); light, (Krimsky, 1982); temperature, (Murrain, 1983); design, (Shea, 1983); and mobility, (Della Valle, 1984) corroborated that thesis.

One of the more important findings of Rosenfeld's research was that:

> ...daylight fluorescent and cool, white light (the most common lighting in classrooms) produces a cold, detached atmosphere. Some white light contains ultraviolet rays which are irritating and may even cause headaches. (p. 169)

Selected information reported concerning environmental lighting appeared to be based either on inappropriate research designs which measured group reactions only or opinion without scientifically obtained substantiation. Other reports were extremely technical in nature and did not lend themselves easily to translation into school-based suggestions. For example, one report, California Lighting Design and Evaluation: A Procedure for the Prediction, Specification, and Evaluation of Visual Comfort and Visual Performance in the Classroom (1978) was a guide intended to aid school administrators, members of school district governing boards, architects, and engineers to objectively evaluate school lighting levels. That document was so technical that most educational administrators could not utilize

it without a prior, extensive knowledge of engineering. The formulae provided required metric equivalents and conversions, as well as interpretations of computer-assisted calculations.

By 1979, King and Marans had conducted a survey of studies that investigated physical environments and the learning process itself. That report was limited in many ways: (a) although it reviewed many publications, it neither related one to the other nor revealed the statistical designs utilized; (b) none of the research included examined the relationship(s) between any of the environmental elements considered and individual preferences; effects were evaluated in terms of majority outcomes with no consideration of pretesting to identify personal characteristics; and (c) many of the studies included were merely observational, some were correlational, and those that were experimental evidenced a focus on group results rather than individual scores in comparison with personal baseline data. The survey revealed however, that with one notable exception (Sampson, 1970), only limited lighting research had been conducted in educational facilities. Sampson's study indicated not only important directions concerning the quality of school lighting, but also implications for energy conservation.

An overview of educational research findings revealed that the data were often conflicting. For example, to create an effective instructional environment, it was deemed important to provide: (a) a variety of stimuli within a homogeneous environment (Feingold, 1971); (b) different activities; little variation produced boredom

and restlessness, and inhibited concentration (Noble, 1970); (c) stability and routines; an overloading of stimuli was considered dangerous; it could impair judgment and rationality (Ruff, 1970); (d) a secure, comfortable feeling (Rosenfeld, 1977); and (e) privacy and individuality; most students needed to be part of the classroom group and, simultaneously, maintain their individuality (Rosenfeld, 1973).

The Dunns had begun reporting interesting information concerning students' reactions to light (1972, 1974, 1975, 1977), but by 1978 the results of their correlational studies evidenced that many underachieving students appeared to prefer poorly illuminated environments when studying, concentrating, or learning. At that time, reports from more than 100,000 students in grades 3-12 across the United States documented that between eight and twelve percent-- dependent on the geographical location-- preferred low light and that the younger the grade level, the less light was desired; the higher the grade level, the more light was requested (Price, 1980). In studies that followed the same youngsters through several grades, increased need for light was indicative of a trend (Dunn, Dunn, & Price, 1984). Many students reported that they could concentrate only in bright light; low light purportedly made them lethargic. Others stated that the reverse was true; low light calmed them and facilitated their ability to absorb and remember, whereas bright light made them "nervous and fidgety" (Dunn, 1983, p. 487).

In 1978, Oexle and Zenhausern revealed that, in a study of poor and good readers, the former were equally divided between left and right preferenced individuals, but 17 of 19 poor readers were right preferenced. That information indicated no relationship with the Dunn's findings until 1982 (Dunn, Cavanaugh, Eberle, & Zenhausern) when an investigation of secondary biology students revealed that predominantly right preferenced students also preferred low light ($p < .01$). Combining the three sets of data, relationships begin to emerge: (a) poor achievers prefer low light (Dunn & Dunn, 1978); (b) right preferenced students prefer low light (Dunn, Cavanaugh, Eberle, & Zenhausern, 1982); (c) good readers are comprised of lefts and rights, but poor readers (17 of 19) are rights (Oexle & Zenhausern, 1980). Certainly that data is not definitive, but it is suggestive of the need for more scrutiny in this area and that Light be considered one element of learning style.

Despite admonitions to provide alternative lighting in physical facilities "to accommodate varying teaching and learning styles" (Krovetz, 1977, p. 3), the following six year period witnessed the emergence of only one experimental investigation in which individuals' learning styles actually were identified and then tested in both congruent and incongruent conditions to determine the effect of matching and mismatching them with specific illumination levels (Krimsky, 1982).

In their volume, Aptitudes and Instructional Methods, Cronbach and Snow (1977) provided future researchers with two challenges.

Their definition of aptitude included characteristics of persons which forecast probabilities of success under specific treatments. Those investigators advocated new measures, including method and style of instruction, teacher variables, and classroom factors to become experimental means. Secondly, their criticism of previous research suggested the transfer of person/environment interaction research from the laboratory to the actual school settings. Thus the concept of aptitude/treatment/interaction as suggested by Cronbach and Snow, coupled with Wurtman's (1968) emphasis on the biological nature of illumination needs and Rosenfeld's (1977) descriptions of how to alter instructional environments to make them more responsive to students' characteristics, served to motivate staff at St. John's University's Center for the Study of Learning and Teaching Styles to investigate Light as one element of learning style.

The First Experimental Study Involving Identified Learning Style Preferences for Bright/Low Light and Academic Achievement

A total population of fourth graders in one affluent, suburban, New York school district was tested with the Learning Style Inventory (LSI) (Dunn, Dunn, & Price, 1979) to identify their preferences for concentrating in either bright or dimly lit areas (Krimsky, 1982). Of the students to whom the instrument was administered, only 32 revealed extreme preferences for either one condition or the

other. That number comprised approximately nine percent of the entire fourth grade population in that district.

Those 32 youngsters then were tested for reading speed and accuracy on a standardized reading test in extremely bright, and then in an extremely dim,instructional setting. Scores on both reading speed and accuracy were consistently significantly higher ($p < .01$) when the illuminated instructional environment matched the student's diagnosed learning style preference for light. Thus, those who preferred Bright Light performed significantly better when tested in the brightly illuminated environment and those who had indicated that they preferred concentrating in Dim Light did equally well when tested in the low-light setting. Both groups performed statistically less well when tested in mismatched situations.

Krimsky's was only the first of much needed experimental research concerned with the effect of light on students who require one or the other of drastically different conditions. Although conflicting research exists on the positive and negative effects of ultraviolet rays, scientists agree that light has a profound influence on individuals' well being. Recently, Hellman (1983) recounted examples of current research and focussed on the dramatic results achieved in the treatment of selected cases of winter depression merely through the control of illumination. The effect of lighting, whether natural or artificial, is a condition of the environment which investigators are going to have to explore further if they wish to provide instructional environments that help--

rather than hinder-- individuals.

Illumination appears to be so important that even seasonal mood changes as strong as depression have been treated successfully merely by increasing the bright, white light in a person's environment (Rovner, 1982). In fact, Rosenthal, a staff psychiatrist, and Wehr, Acting Chief of Clinical Psychobiology at the National Institute of Mental Health, documented both the onset of depression and the mood elevations that resulted after lights were added; they also found that relapses occurred when the amount of light was reduced. Those researchers' findings that individuals are susceptible to the extremes of negativism when concentrating in inappropriate illumination appears to support the biological basis of learning style as reported by Thies (1979) and Schmeck and Lockhart (1983). Light is one element of learning style; it is likely that we have not yet begun to understand its full impact on individual achievement.

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